2910

JPRS: 2910

29 June 1960

AUTOMATIC EQUIPMENT AT SEISMIC STATIONS OF THE NORTH TIEN SHAN ZONE

- USSR -

A. A. Fogel'

Distributed by:

OFFICE OF TECHNICAL SERVICES
U. S. DEPARTMENT OF COMMERCE
WASHINGTON 25, D. C.
[redacted]

U. S. JOINT PUBLICATIONS RESEARCH SERVICE
205 EAST 42nd STREET, SUITE 300
NEW YORK 17, N. Y.

JPRS: 2910

CSO: 4048-N

AUTOMATIC EQUIPMENT AT SEISMIC STATIONS OF THE NORTH TIEN SHAN ZONE

/Following is a translation of an article by A. A. Fogel' in Izvestiya Akademii Nauk SSSR, Seriya Geofizicheskaya (News of the Academy of Sciences USSR, Geophysical Series), No. 2, Moscow, 1960, pages 229-235./

Description of equipment used at seismic stations of the North Tien Shan zone, intended for automatic channel elevation, introduction of multistage coarse tuning and notification during registration of earthquakes.

Many seismic stations are fitted out with equipment which it is customary to call signalizers. A signalizer has to provide, first of all, a clear, readable record of weak as well as strong earthquakes, and, secondly, signalization proper (sound and optical) about the recording of earthquakes.

In order to solve the first problem it is necessary to increase the heating of collimator tubes during the recording of an earthquake and to introduce coarse tuning of the instruments so that its operational increase would provide a readable record of all phases of the earthquake. To achieve this, it is expedient to change the coarse tuning coefficient according to the amplitude of oscillations.

The term "signalizer" is no longer appropriate for an apparatus which performs these operations automatically. It would be more correct to call it an apparatus for automatic heating increase, coarse tuning and notification (APZO). An APZO schematic has to satisfy the following demands: maximal automatism; operational stability; economy in the consumption of electricity; adaptability for stations of the general type as well as for teleseismic and regional stations.

Several schematics of signalling apparatus are described in the literature. A photoelectrical signalizer, constructed by A. E. Ostrovskiy /1/, provides only notification, although the schematic, with a small change, could yield higher heating of the collimator tubes. Its large consumption of energy, however, makes this schematic impractical for use at stations without an AC supply or where the flow of current is irregular.

I. L. Nersesov's contact signalizer /2/ is intended for re-

cording only strong earthquakes. A disadvantage of V. I. Solov'yev's signalizer [3] consists in the simultaneity of switching on the increase of heating and coarse tuning, which could prevent the readability of the records of small earthquakes.

A two-stage signalizer, installed at the "Moscow" Seismic Station [4], permits, because of the ingenious utilization of two supplementary collimators, switching on additional heating with a small amplitude of oscillation and switching on coarse tuning with a greater oscillation amplitude. The wide range of amplitude change during earthquakes of different strengths, however, makes one-stage coarse tuning insufficient, and the schematic does not provide for changes of the coarse tuning coefficient in relation to the amplitude.

A schematic for automatically increasing the heating of collimator tubes was first installed in 1950 at the "Alma-Ata" Seismic Station. In 1952, an APZO apparatus for the introduction of three-stepped coarse tuning with coefficients 5, 25 and 125 was constructed at the same station.

Towards 1956, an APZO apparatus which satisfied all the above-listed specifications was in operation at the Central "Alma-Ata" Seismic Station, as well as at the regional stations of the North Tien Shan zone ("Kurmenty", "Chilik", "Ili", and "Fabrichnaya"). At the "Alma-Ata", "Chilik" and "Kurmenty" stations three-stage coarse tuning is provided. At the "Ili" and Fabrichnaya" stations it was found possible to limit coarse tuning to one-stage ($\beta = 5$).

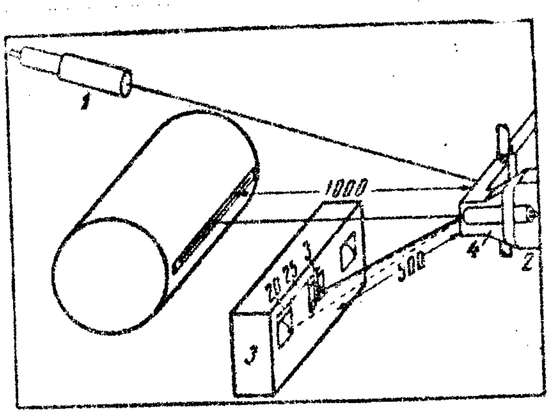

Fig. 1. Diagram of the optical part of the APZO
1 - additional collimator; 2 - galvanometer; 3 - photoelement; 4 - coarse-tuning marker.

According to the operating principle, the APZO is a photoelectric device with dry-cell feeding. The operation of the device is completely automatic, and continuous operation is assured only by prophylactic cleaning of relay contacts, as well as by a change of the batteries once every six months.

The optical part of the APZO (Fig. 1) consists of three photoelements STsV-3 (or STsV-4), an additional collimator 1 and the coarse-tuning marker.

A ray from collimator 1, reflected from the mirror of one of the operating galvanometers 2, falls on the crosspiece of the middle window of the photoelement block 3. At the distances and dimensions (mm) given in Fig. 1, at a light-recording amplitude from 3 mm and above, the reflection of the light-beam is displaced from the crosspiece to the middle photoelement. At the same time, the heating of the collimator tubes is increased.

At a recording amplitude from 70 mm and above, the ray falls

at one of the outside photoelements, which are connected in parallel. In that case, the first stage of coarse tuning cuts in. A new increase of amplitude to 70 mm will cause the connection of the second stage of coarse tuning, etc.

The coarse tuning marker 4 is a small light source with a slotted diaphragm 0.3 - 0.4 mm wide. The marker is fastened to one of the galvanometers in such a way that its slot is parallel to the cylindrical lens of the recorder. The ray of the marker has to lie in one plane with the operating rays. The bulb of the marker gives a short flash when the coarse tuning is connected. The image of the slot falls on the cylindrical lens and is focused by it. After development, a clear horizontal line appears on the seismogram.

The electrical lay-out of the APZO (Fig. 2) consists of three basic units: a photo-cell block with amplifiers and the coarse tuning panel are located in the registration compartment; an operating panel with control and signalization boards as well as the basic relays are located in the service compartment.

Two one-tube amplifiers with 2P1P tubes are employed in the schematic. The leakage resistors R_1, R_2 are equal to 300-1000 megohms. The vacuum photo-cells STsV-3 (or STsV-4) have a very small dark current. Together with carefully-installed insulation of grid chains, this assures absolutely reliable and stable operation of the photorelays. The grid displacement (battery B_1) constitutes 9V. The operating point of the amplifiers is set by means of a change of voltage on screen grids by means of potentiometers R_3, R_4 (1.5 megohm). Optimal screen voltage constitutes 35-40 V.

Polarized relays R_1 and R_4 are connected as anode loads. They are tuned to operate from 50-100 μa current.

R_2 - polarized relay, connected according to the diagram of a time relay, with a switch-off delay of 12-15 sec. R_{10} - polarized relay of the time marker. One winding of this relay is connected through a detector to the output transformer of a radio receiver, which permits semi-automatic reception of correct time signals on the seismogram. R_3, R_5, R_7, R_8, R_9 - any multicontact relays with matching voltage; R_6 - pitch relay with two electromagnets, providing rotor movement in direct and reverse directions. The relay is assembled from two telephone-type selectors. R_{11} - polarized relay, signaling the burning-out of collimator tubes. It has a low-ohm winding (40 turns of the PEL = 0.8 wire), connected serially to the collimator chain, and a high-ohm coil (of 500-ohm order), connected in parallel to the collimators. The magnetic fields of these windings compensate each other in the basic position. If collimator tubes burn out, the increase of current flow in the high-ohm coil and a simultaneous decrease of current flow in the low-ohm winding cause the connection of relay R_{11}; signal lamp L_7 lights up and the bell Zv_1 is connected.

All tumbler switches and relays in the APZO diagram in Fig. 2 are in the basic operating position.

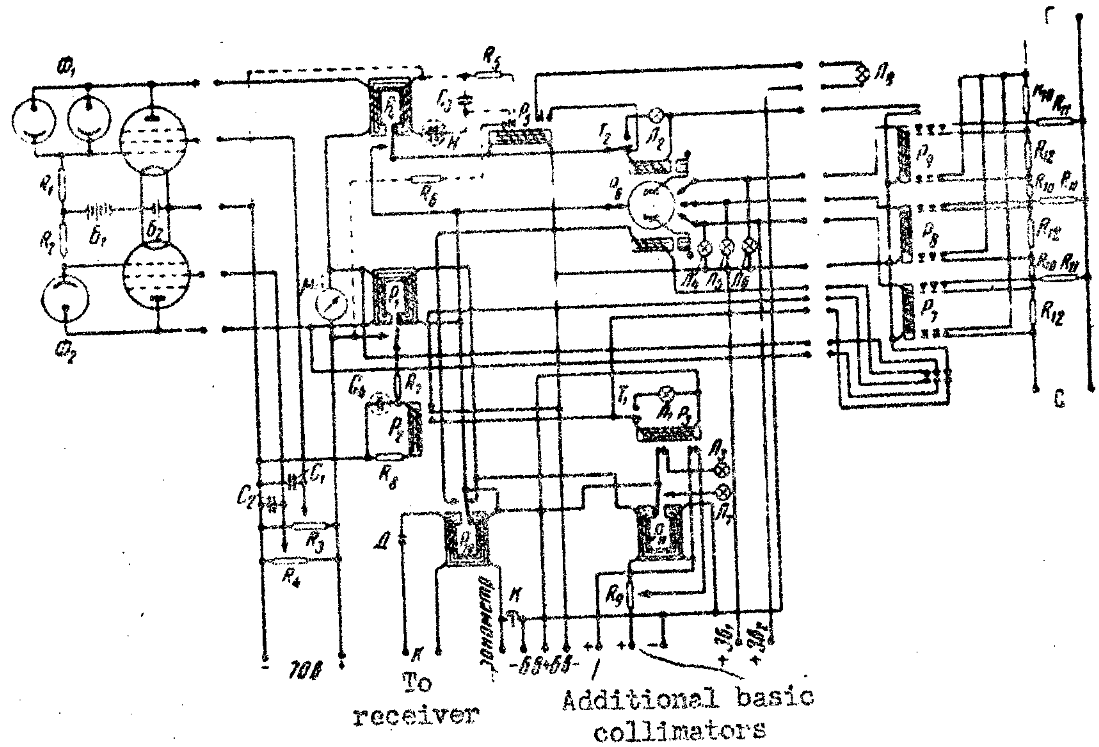

Fig. 2. Principle diagram of the APZO

When the light falls on the middle photoelement F_2, the R_1 relay is connected and, immediately following, relay R_2. At the same time, condenser C_4 (30 mfd) is charged through resistor R_7 (20 kiloohm). Relay R_2 connects relay R_3, which shortens part of the resistor R_9 (5-7 ohm), increasing the heating of the illuminator tubes and connecting signal light L_3 and bell Zv_1.

After the termination of the earthquake, the reflection of the lightbeam moves again to the breaker winding of relay R_8, and brings the relay, upon the time signal mark, to the basic position. Condenser C_4, upon discharge through resistor R_8 (200 kiloohm), keeps the contacts of the relay R_2 closed for 12-15 sec. After relay R_2 is disconnected, relay R_3 is disconnected and the heating is lowered to normal.

In the case when the oscillation amplitude is sufficiently high the light falls on one of the outside photocells F_1, and relay R_4 is connected, closing the circuit of the winding of relay R_5. At station equipped with the general apparatus, the relay R_4 is adjusted to a regime of unilateral engagement; the part of the schematic drawn in a dotted line is absent and relay R_5 is employed only for the connection of the tube L_8 of the coarse-tuning marker. At regional stations, relay R_4 is adjusted to a regime of two-sided engagement and is brought to the basic position by the breaker cell with neon lamp N,

resistor R_6 (1 megohm) and condenser C_3 (0.5 mfd). The time constant of this cell constitutes 0.5 sec. The use of such a schematic assures practically vibration-proof operation of the device, which is very important in the case of recording close and especially local earthquakes, when the illumination pulses of photo-cells are very short.

Through tripping relay R_4, the voltage reaches the connector winding of the step relay R_6. Its rotor makes a single turn and closes the circuit of the coil relay R_7 of the first coarse tuning stage. At the same time the signal lamp L_4 lights up and the bell Zv_2 is connected. Besides the connection of coarse tuning shunts, relay R_7 also accomplishes three pairs of contacts - one, increasing the heating of the collimators; second, breaking the circuit of the breaking coil of the step relay, and third, closing and shortening the coil of relay R_1.

With another increase of the recording amplitude to 70 mm, the processes which are described above are repeated. The step relay makes another step. The second stage of coarse tuning cuts in and signal lamp L_5 is lit. The third stage of coarse tuning is connected in the same way. Relay R_9 of the last stage breaks the circuit of the connector coil of the step relay and further amplitude increase will not cause this relay to flip.

Switching off of coarse tuning can begin only after the delay relay R_2 assumes the basic position. After this the alternate time mark will transfer the step relay one stage backward. In the same manner other stages of coarse tuning are also disconnected. However, because of additional contacts of relay R_7, the heating increase cannot be disconnected until fine tuning is effected. Together with the utilization of the delay relay, it assures constant increased heating during all of the earthquake, which substantially betters the quality of the record.

In the coarse tuning panel the usual triple Golitsyn shunts are used. It is expedient to increase the coarse tuning coefficient in a geometrical progression. In addition, the shunts for all three stages of coarse tuning are of the same size and are connected in consecutive units.

In relays R_7, R_8, R_9 contact groups are, by means of a simple alteration, removed from the winding and are insulated from their thermal influence as much as possible. This measure decreases thermal currents, which develop in galvanometer circuits when coarse tuning is connected. Nevertheless, with the connection of coarse tuning, because of the great sensitivity of galvanometers, some displacement of zero points is observed, which could be sufficient to cause the light beam to drift from the crosspiece of the photo-cell unit. This would keep the increase of heating and coarse tuning would remain connected after they were no longer needed. In order to avoid this, winding of relay R_1 is shunted during the period of coarse tuning.

A short flash of lamp L_8 during the time of the coarse tuning

marker is assured by the use of a special contact group on relay R_5.

Tuning of the APZO is performed with the switches T_1 and T_2 transferred from the operating to the upper position (Fig. 2). In this case, on the flipflop of the photorelay and on the closing of contacts of relay R_2, instead of increased heating, bulb L_1 will light up, and after the closing of contacts of relay R_4, instead of the connection of the pitch relay, bulb L_2 will light up (at the same time the marker of coarse tuning will not operate). This makes it possible to perform tuning during recording time.

Tuning is done in the following order. An anode current of 15-20 μa, smaller than the current of operating relay R_1, is established by potentiometer R_4 and tested by a microammeter and bulb L_1. The heating increase photorelay appears to be sufficiently close to the operating threshold at this time.

In the same way, a second potentiometer R_3, bulb L_2 and the same microammeter are used for the adjustment of the coarse tuning relay. Switches T_1 and T_2 are returned to the operating position after adjustment.

Readjustment and inspection of the position of the operating points of photocurrent amplifiers is performed under normal conditions not more often than once every 2-3 months.

Lower for the photorelay is supplied by dry cells: BNS-MVD-500 for heating (B_2) and BAS-90 as a source of anode voltage. Two cells of the KBS (B_1) type provide a grid displacement of 9V. Only half of the filaments in the 2P1P tubes are connected; the general heating current constitutes 0.12a. Total anode current of both photoreleys in their basic position constitutes 100-200 μa. Grid batteries are disconnected only as a result of self-discharge.

In order to prevent an influence of the connection of the APZO on the heating of the collimator tubes, the power supply of all relays and signal devices is achieved by means of a separate battery of accumulators.

During 1956-1957, regional seismic stations of the North Tien Shan zone obtained more than 6000 records of earthquakes. During the same period, the Central "Alma-Ata" Seismic Station registered more than 1000 earthquakes by means of the general type equipment. The APZO systems have operated smoothly in all of these observations.

At the "Alma-Ata" station, during 1957, eight earthquakes were registered when one-stage coarse tuning ($\beta = 5$) was connected, two earthquakes when two stages of coarse tuning ($\beta = 25$) were connected, and three when two stages ($\beta = 125$) were connected.

For instance, in case of the Mongolian earthquake of 4 December 1957, the maximal amplitudes were registered with coarse tuning on the order of 125. For the total increase in the conversion for the displacement of a writing light point along a tape, the amplitude would be 10 m. In that case, not only could a record not be obtained but even the galvanometers could be put out of commission.

Fig. 3 represents a seismogram of the 9 June 1956 earthquake,

recorded at the "Alma-Ata" Seismic Station ($\Delta \approx 12^{\circ}$, $M \approx 7$). During the recording, coarse tuning of the 5, 25 and 125 orders was consecutively connected, thus making a record of earth displacements with an amplitude above 3000μ readable along its entire length. During this earthquake, marking of the moment of coarse tuning was achieved differently than in the last variant of the APZO. An additional collimator, the tube heating of which was changed in accordance with the coefficient of coarse tuning, was used here for marking coarse tuning. Such a system of marking the moment of coarse tuning required a certain change of the schematic and was later changed.

The described schematic can be used with slight alteration at stations equipped with several sets of seismic apparatus of various types.

At the Central "Alma-Ata" Seismic Station, for instance, besides galvanometric and optical recording by equipment of the general type, mechanical recording by the SMP type apparatus is performed. At the beginning of an earthquake, at the same time as the increase of collimator-tube heating, collimators of optical recording are connected and SMP recording devices and optical recording are set into operation.

If the earthquake is weak and distant, the SMP and optical recording is disconnected after 0.5 min. If the coarse tuning is connected, then the SMP and optical recording are connected until the time when the SMP drums complete their rotation. During sufficiently strong local earthquakes, the connection of SMP and optical recording is accomplished by a relay, connected to a special coil, located on a damping plate of one of the SMP seismographs.

[Fig. 3 on the next page]

Conclusions.

1. Equipment with automatic heating increase, coarse tuning, and notification, used at seismic stations of the North Tien Shan, assures: a) a clear, readable record of earthquakes, including strong distant earthquakes of any strength; b) notification to the station personnel of the progress of the earthquake recording as well as of the burning-out of collimator tubes; c) semi-automatic recording on tape of correct time signals.

2. The virtue of the schematic consists in the possibility of its application at regional stations, as well as at stations of the general type.

3. Use of the APZO equipment at seismic stations of the North Tien Shan zone has facilitated bettering of the quality of earthquake records at these stations.

Academy of Sciences of the USSR
Institute of Earth Physics

Received
23 June 1959

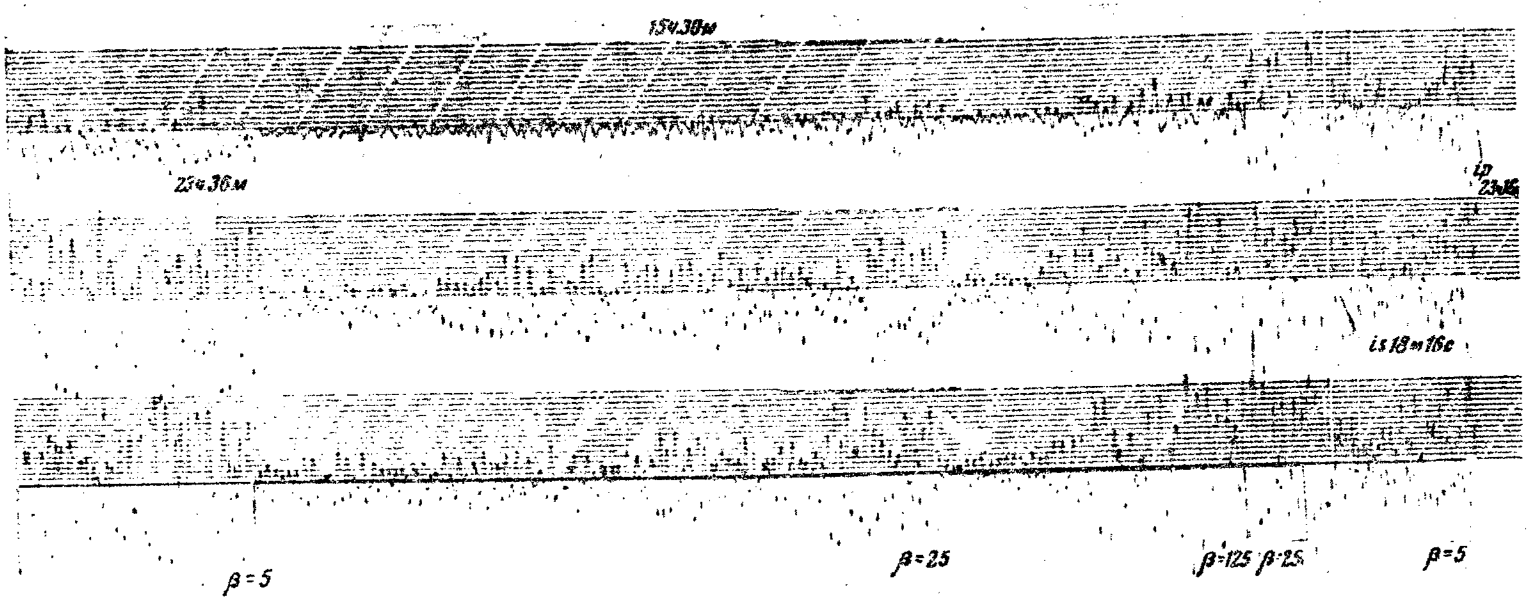

Fig. 3. Seismogram of the earthquake of 9 June 1956
"Alma-Ata" station.

Bibliography

1. Ostrovskiy A. E. Signalizer of Strong Earthquakes. Tr. Geofiz. in-ta AN SSSR (Trans. of the Geophysical Institute of the AS USSR), No. 9 (136), 1950.
2. Nersesov I. L. Signalizer of Nearby Earthquakes. Tr. Geofiz. in-ta AN SSR (Trans. of the Geophysical Institute of the AS USSR), No. 21 (148), 1953.
3. Solovyev, V. N. Photoelectric Signalizer of Strong Earthquakes. Tr. Geofiz. in-ta AN SSR, (Trans. of the Geophysical Institute of the AS USSR), No. 30 (157), 1955.
4. Shebalin N. V. An Experience of Instrumental Observations at the Central "Moscow" Seismic Station, Tr. Geofiz. in-ta AN SSR, (Trans. of the Geophysical Institute of the AS USSR), No. 30 (157), 1955.